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Acute Coronary Occlusion in Patients With Non-ST-Segment Elevation Out-of-Hospital Cardiac Arrest

Alessandro Spirito, MD,[a,b] Lukas Vaisnora, MD,[a] Athanasios Papadis, MD,[a] Fortunato Iacovelli, MD, PhD,[c] Celestino Sardu, MD, MS, PhD,[d] Alexandra Selberg, MA,[b] Sarah Bär, MD,[a] Raminta Kavaliauskaite, MD,[a] Fabrice Temperli, MD,[a] Babken Asatryan, MD, PhD,[a] Thomas Pilgrim, MD,[a] Lukas Hunziker, MD,[a] Dik Heg, PhD,[e] Marco Valgimigli, MD, PhD,[f] Stephan Windecker, MD,[a] Lorenz Räber, MD, PhD[a]

ABSTRACT

BACKGROUND According to current guidelines, hemodynamic status should guide the decision between immediate and delayed coronary angiography (CAG) in out-of-hospital cardiac arrest (OHCA) patients without ST-segment elevation. A delayed strategy is advised in hemodynamically stable patients, and an immediate approach is recommended in unstable patients.

OBJECTIVES This study sought to assess the frequency, predictors, and clinical impact of acute coronary occlusion in hemodynamically stable and unstable OHCA patients without ST-segment elevation.

METHODS Consecutive unconscious OHCA patients without ST-segment elevation who were undergoing CAG at Bern University Hospital (Bern, Switzerland) between 2011 and 2019 were included. Frequency and predictors of acute coronary artery occlusions and their impact on all-cause and cardiovascular mortality at 1 year were assessed.

RESULTS Among the 386 patients, 169 (43.8%) were hemodynamically stable. Acute coronary occlusions were found in 19.5% of stable and 24.0% of unstable OHCA patients ($P = 0.407$), and the presence of these occlusions was predicted by initial chest pain and shockable rhythm, but not by hemodynamic status. Acute coronary occlusion was associated with an increased risk of cardiovascular death (adjusted HR: 2.74; 95% CI: 1.22-6.15) but not of all-cause death (adjusted HR: 0.72; 95% CI: 0.44-1.18). Hemodynamic instability was not predictive of fatal outcomes.

CONCLUSIONS Acute coronary artery occlusions were found in 1 in 5 OHCA patients without ST-segment elevation. The frequency of these occlusions did not differ between stable and unstable patients, and the occlusions were associated with a higher risk of cardiovascular death. In OHCA patients without ST-segment elevation, chest pain or shockable rhythm rather than hemodynamic status identifies patients with acute coronary occlusion. (J Am Coll Cardiol 2023;81:446–456) © 2023 by the American College of Cardiology Foundation.

Out-of-hospital cardiac arrest (OHCA) is a leading cause of death worldwide.[1] Despite the advances in cardiopulmonary resuscitation (CPR) and intensive care management, mortality remains high.[2] Nearly 70% of OHCA patients have relevant coronary artery disease (CAD),[3,4] and up to 50% present with an acute coronary artery occlusion warranting percutaneous

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From the [a]Department of Cardiology, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland; [b]The Zena and Michael A. Weiner Cardiovascular Institute, Icahn School of Medicine at Mount Sinai, New York, New York, USA; [c]Division of University Cardiology, Cardiothoracic Department, Polyclinic University Hospital, Bari, Italy; [d]Department of Advanced Medical and Surgical Sciences, University of Campania Luigi Vanvitelli, Naples, Italy; [e]Bern Clinical Trials Unit, University of Bern, Bern, Switzerland; and the [f]Cardiocentro Ticino, Ente Ospedaliero Cantonale, Università della Svizzera Italiana, University of Lugano, Lugano, Switzerland.

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coronary intervention (PCI).[5,6] Yet, in OHCA patients presenting without ST-segment elevation, acute coronary lesions are less frequent findings not reliably predicted by electrocardiography (ECG) changes and troponin values.[7-9] International guidelines recommend immediate coronary angiography (CAG) in unconscious OHCA patients with ST-segment elevation.[10,11] In the absence of ST-segment elevation, immediate (ie, <2 hours) CAG is recommended in hemodynamically unstable patients, whereas delayed CAG is advised for hemodynamically stable patients.[10-12] The latter recommendation is based on the results of 2 recent randomized controlled trials (RCTs), TOMAHAWK (Immediate Unselected Coronary Angiography Versus Delayed Triage in Survivors of Out-of-hospital Cardiac Arrest Without ST-segment Elevation)[13] and COACT (Coronary Angiography After Cardiac Arrest),[14] which showed no mortality benefit of an immediate invasive strategy as compared with a delayed invasive strategy in hemodynamically stable OHCA patients without ST-segment elevation. The proportion of patients with relevant CAD or acute coronary occlusions in these 2 RCTs was lower than in previous observational studies including both stable and unstable patients.[15-17] Hence, it remains unclear whether the frequency of acute coronary occlusions in OHCA patients without ST-segment elevation varies according to hemodynamic status and whether it is appropriate to recommend immediate CAG only for patients presenting with hemodynamic instability.

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The aim of our study was to assess the frequency, predictors, and clinical impact of acute coronary occlusion on mortality in hemodynamically stable and unstable OHCA patients without ST-segment elevation in a single tertiary center cohort.

METHODS

Bern University Hospital (Bern, Switzerland) is the only referral center for OHCA patients in an area with a population of 1.2 million inhabitants. OHCA patients can be directly transported to the catheterization laboratory by the emergency medical service in agreement with the invasive cardiologist or are referred to the emergency department for a diagnostic work-up. Less frequently, OHCA patients are admitted to the emergency department of a regional hospital and are subsequently transferred to Bern University Hospital. All consecutive patients who were resuscitated from OHCA and who underwent CAG at Bern University Hospital between January 1, 2011 and December 31, 2019 were included in the prospective Bern OHCA Registry, which conforms to the principles of the Declaration of Helsinki and was approved by the local Ethics Committee of Bern. All patients providing informed consent were included without formal exclusion criteria. A waiver of informed consent was allowed for patients who died before study enrollment. The definition of OHCA was cessation of cardiac activity with hemodynamic collapse requiring defibrillation and/or chest compressions to restore spontaneous circulation occurring in patients outside hospital care.[18] Patients who experienced a cardiac arrest at first in the emergency department and not a recurrent arrest after a previous out-of-the hospital resuscitation were not considered to have OHCA.[19] Demographic, clinical, anatomical, and procedural characteristics, laboratory values, and outcomes up to 1 year after OHCA of patients who underwent PCI were prospectively obtained.

At 1 year after OHCA, all patients who were still alive received a health questionnaire with questions on rehospitalization and any adverse events (including bleeding and ischemic occurrences); in case of missing responses, patients were contacted by telephone by trained personnel. General practitioners, referring cardiologists, and other medical institutions were reached as needed to collect discharge letters, CAG or PCI reports, or any other relevant medical records. Survival data were obtained from hospital records and municipal civil registries.

According to previous European Society of Cardiology guidelines for patients without ST-segment elevation acute coronary syndrome (2011 and 2015), immediate CAG (≤2 hours) was recommended for patients resuscitated from OHCA without a clear noncoronary cause of the cardiac arrest, irrespective of hemodynamic status or ST-segment changes.

On the basis of the admission records of 2018 and 2019, 86% of OHCA patients who survived at hospital admission and who had no clear noncoronary cause of the cardiac arrest were referred to CAG. Reason for nonreferral to CAG were perceived poor prognosis, absolute contraindication to CAG or PCI (eg, acute intracranial hemorrhage, severe acute kidney injury), or perceived low likelihood of an acute coronary syndrome (Supplemental Figure 1). The type and timing of antithrombotic therapy, the need for PCI, and the extent of revascularization were left to the discretion of the treating physicians, following local

ABBREVIATIONS AND ACRONYMS

CAD = coronary artery disease

CAG = coronary angiography

CPR = cardiopulmonary resuscitation

ECG = electrocardiography

MI = myocardial infarction

OHCA = out-of-hospital cardiac arrest

PCI = percutaneous coronary intervention

RCT = randomized controlled trial

TIMI = Thrombolysis In Myocardial Infarction and international recommendations. In patients undergoing PCI, the routinely prescribed dual antiplatelet therapy (DAPT) duration was 12 months, whereas for patients receiving concomitant oral anticoagulation therapy, DAPT duration did not exceed 6 months.

For the purpose of the current analysis, only unconscious OHCA patients without evidence of ST-segment elevation on 12-lead ECG on hospital admission were considered. In alignment with the COACT trial protocol, conscious patients were not included because their prognosis differs from that of unconscious patients.[20] Patients without ECG before CAG were excluded. The study group was stratified according to hemodynamic status into stable and unstable OHCA. In agreement with the definitions used in the 2 largest RCTs on OHCA patients (COACT and TOMAHAWK),[13,14] a study participant was categorized as having unstable hemodynamic status if receiving treatment with intravenous catecholamine for >30 minutes or mechanical hemodynamic support or ongoing CPR at the time of hospital admission.

ANGIOGRAPHIC FINDINGS. Coronary angiograms were reviewed by experienced interventional cardiologists. Lesions resulting in >50% stenosis in luminal diameter according to visual estimate were considered relevant. Acute coronary artery occlusion was defined as a lesion causing severe coronary flow impairment, defined as Thrombolysis In Myocardial Infarction (TIMI) flow grade 0 or 1, and with evidence of thrombus.

CLINICAL ENDPOINTS. The following outcomes were assessed up to 1 year after the index cardiac arrest: all-cause death; cardiovascular death; myocardial infarction (MI); definite stent thrombosis; unplanned coronary revascularization; any stroke (ischemic or hemorrhagic); and bleeding type 3 or 5 according to Bleeding Academic Research Consortium (BARC) classification.[21]

A clinical event committee composed of 2 cardiologists adjudicated all fatal, ischemic, and bleeding events against original source documents in accordance with standardized definitions. MI was defined according to the modified historical definition,[22] whereas stent thrombosis was defined using the Academic Research Consortium definition.[23] Further details on definitions are available in the Supplemental Methods.

STATISTICAL ANALYSIS. Baseline, anatomical, and procedural characteristics are shown as mean ± SD or as counts with percentages; *P* values for comparisons between hemodynamically stable vs unstable OHCA were obtained using Student's *t*-tests, Fisher exact tests, or chi-square tests, as appropriate.

Logistic regression model was used to identify predictors of acute coronary occlusion (acute lesions with TIMI flow grade 0-1); the variables included in the final model were selected through a forward stepwise approach with a criterion for inclusion of $P < 0.20$ from a pool of 18 variables.

Clinical event rates at 1 year were obtained using the Kaplan-Meier method and were compared using the log-rank test. Unadjusted risks for the clinical outcomes in hemodynamically unstable vs stable patients were calculated with univariate Cox regression analyses. Adjusted risks for all-cause and cardiovascular death were calculated with multivariable Cox regression analyses with a forward stepwise selection approach with a criterion for inclusion of $P < 0.20$ from a pool of 24 variables. The risks were expressed as HRs with 95% CIs.

Analyses were performed using in Stata software release 16.1 (StataCorp, LLC).

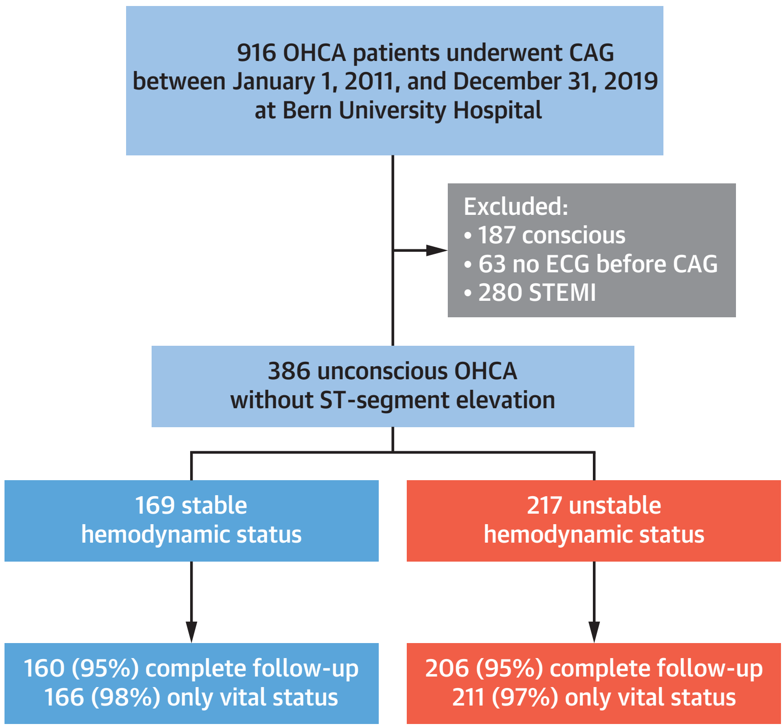
RESULTS

PATIENT CHARACTERISTICS. Among 916 OHCA patients who underwent CAG at Bern University Hospital between January 2011 and December 2019, 187 (20.4%) who were conscious on hospital admission, 63 (6.9%) who had no available ECG before CAG, and 280 (30.6%) who had ST-segment elevation were excluded from the current analysis. The study group consisted of 386 unconscious OHCA patients without ST-segment elevation, 169 (43.8%) hemodynamically stable and 217 (56.2%) unstable. Vital status at 1 year was known for 98% of stable OHCA patients and for 97% of unstable OHCA patients, whereas complete 1-year outcome data were available for 95% of patients in both groups (**Figure 1**).

Hemodynamically stable OHCA patients compared with hemodynamically unstable OHCA patients were younger, were less likely to have diabetes or renal failure, and had more frequently favorable cardiac arrest parameters, such as initial shockable rhythm, shorter CPR duration, and lactate and pH values in the normal range (**Tables 1 and 2**). Patients with stable OHCA also had better renal function (ie, a higher glomerular filtration rate) and platelet counts on hospital admission (Supplemental Table 1).

ANGIOGRAPHIC FINDINGS. The median time between cardiac arrest and CAG was 2.2 hours in both

FIGURE 1 Patient Inclusion Flow Diagram



Among all unconscious patients after out-of-hospital cardiac arrest (OHCA) who were referred to the catheterization laboratory of the Bern University Hospital (Bern, Switzerland), those patients without ST-segment elevation on electrocardiography (ECG) on hospital admission were included and stratified according to their hemodynamic status. CAG = coronary angiography; STEMI = ST-segment elevation myocardial infarction.

stable and unstable OHCA patients. CAG was performed within 6 hours of hospital admission in 92% of stable OHCA patients and in 96% of unstable OHCA patients (Table 1).

Approximately two-thirds of stable and unstable OHCA patients had a relevant coronary lesion (63% vs 62%, respectively: $P = 0.833$). An acute coronary occlusion was found in 33 (19%) stable and 53 (24%) unstable OHCA patients ($P = 0.407$) (Central Illustration). There were no relevant differences concerning localization of the culprit lesion (Figure 2).

In multivariable analysis, chest pain before cardiac arrest (adjusted HR: 2.70; 95% CI: 1.35-5.41; $P = 0.005$) and a shockable rhythm (adjusted HR: 2.67; 95% CI: 1.35-5.28; $P = 0.005$) were independently associated with the presence of an acute coronary artery occlusion. Higher troponin values (adjusted HR: 1.11; 95% CI: 0.99-1.25; $P = 0.068$) were borderline related with an acute coronary occlusion, and hemodynamic instability (adjusted HR: 1.00; 95% CI: 0.58-1.73; $P = 0.992$) did not emerge as an independent predictor of acute coronary occlusion (Central Illustration, Supplemental Table 2). PCI was performed in 81 (48%) stable OHCA patients and in 101 (47%) unstable OHCA patients. Further details of procedural characteristics and antithrombotic therapy are presented in Supplemental Tables 3 and 4.

CLINICAL OUTCOMES. At 1-year, all-cause death had occurred in 73 (43.3%) stable OHCA patients and in 129 (59.6%) unstable OHCA patients (HR unstable vs stable: 1.62; 95% CI: 1.22-2.16; $P = 0.001$) (Table 3). After multivariable adjustment, age, nonshockable rhythm, unwitnessed cardiac arrest, longer time between cardiac arrest and start of bystander or professional CPR (no-flow time), and CPR duration were associated with an increased hazard of death.

TABLE 1 Baseline Characteristics

	Stable OHCA (n = 169)	Unstable OHCA (n = 217)	*P* Value[a]
Age, y	169, 62.1 ± 14.1	217, 66.8 ± 12.1	<0.001
Female	169, 28 (17)	217, 45 (21)	0.359
Body mass index, kg/m^2	130, 26.6 ± 4.2	180, 27.0 ± 4.7	0.370
Former or current smoker	169, 58 (34)	215, 67 (31)	0.513
Arterial hypertension	169, 88 (52)	216, 116 (54)	0.759
Hypercholesterolemia	169, 64 (38)	216, 81 (38)	1.000
Positive family history	169, 22 (13)	216, 32 (15)	0.659
Diabetes mellitus	169, 19 (11)	216, 43 (20)	0.025
Previous myocardial infarction	169, 33 (20)	216, 46 (21)	0.704
Previous PCI	169, 41 (24)	217, 47 (22)	0.544
Previous CABG	169, 25 (15)	216, 24 (11)	0.286
Peripheral arterial disease	169, 17 (10)	216, 16 (7)	0.366
Previous stroke	169, 11 (7)	216, 16 (7)	0.842
History of atrial fibrillation	169, 31 (18)	216, 43 (20)	0.795
Previous cardiomyopathy	166, 30 (18)	216, 28 (13)	0,196
Previous cardiac arrest	169, 7 (4)	217, 5 (2)	0.380
Pacemaker	169, 4 (2)	217, 7 (3)	0.762
History of bleeding	169, 13 (8)	216, 16 (7)	1.000
History of malignancy	169, 12 (7)	216, 20 (9)	0.465
Chronic obstructive lung disease	169, 23 (14)	216, 30 (14)	1.000
Chronic kidney disease	169, 19 (11)	217, 41 (19)	0.047
Previous venous thromboembolism	169, 7 (4)	217, 13 (6)	0.492
Autoimmune disease	169, 6 (4)	217, 8 (4)	1.000
Chronic liver disease	169, 5 (3)	217, 1 (0)	0.090
LVEF, %	154, 43.6 ± 15.6	197, 40.9 ± 17.3	0.129
CK on admission, U/L	159, 1,370 ± 10,856	197, 442 ± 641	0.232
Troponin on admission, ng/L	160, 485 ± 1,294	198, 684 ± 2,488	0.361
Ongoing CPR	169, 0 (0)	217, 15 (7)	–
Mechanical hemodynamic support	169, 0 (0)	217, 22 (10)	–
Time from CA to CAG, h	160, 2.2 (1.6-2.9)	211, 2.2 (1.7-3.0)	0.785
Time from door to needle, h[#]	153, 0.9 (0.5-1.5)	205, 1.0 (0.7-1.6)	0.203
<6	141 (92)	197 (96)	0.189
6-24	3 (2)	4 (2)	
>24	5 (3)	1 (0)	
PCI	169, 81 (48)	217, 101 (47)	0.837
Therapeutic hypothermia	168, 153 (91)	211, 165 (78)	0.001
Days from CAG to discharge	102, 17.0 ± 11.5	90, 17.3 ± 13.0	0.863

Values are n, mean ± SD, n (%), or median (IQR). [a]*P* values from Student's *t*-tests (continuous variables), chi-square tests (counts), or Fisher exact test (2×2 comparisons).

CA = cardiac arrest; CABG = coronary artery bypass graft; CAG = coronary angiography; CK = creatine kinase; CPR = cardiopulmonary resuscitation; LVEF = left ventricular ejection fraction; OHCA = out-of-hospital cardiac arrest; PCI = percutaneous coronary intervention.

Unstable hemodynamic status and acute coronary occlusions were not independent predictors of death (**Figure 3A,** Supplemental Table 5).

Cardiovascular death occurred in 20 (14.6%) stable and 48 (27%) unstable OHCA patients (HR unstable vs stable: 2.17; 95% CI: 1.29-3.66; $P = 0.004$) and represented 27% and 37% of all fatalities in the 2 groups, respectively (**Table 3**). Cardiovascular deaths tended to occur earlier than noncardiovascular deaths (Supplemental Figure 2). After adjustment, nonshockable rhythm, higher glucose levels, and acute coronary occlusion, but not unstable hemodynamic status, emerged as independent predictors of cardiovascular mortality (**Figure 3B**, Supplemental Table 6).

No significant differences were observed for any of the ischemic or bleeding outcomes (**Table 3**).

DISCUSSION

We assessed the frequency and predictors of acute coronary occlusion, as well as its impact on adjudicated clinical outcomes at 1 year in a cohort of unconscious OHCA patients without ST-segment elevation who underwent CAG.

The main findings can be summarized as follows:

- The frequency of acute coronary occlusion was approximately 20% without a difference between hemodynamically stable and unstable OHCA patients.
- The presence of acute coronary occlusion was predicted by chest pain before cardiac arrest and a shockable rhythm.
- Hemodynamic instability did not emerge as a predictor of acute coronary occlusion.
- Acute coronary occlusion was associated with a nearly 3-fold higher risk of cardiovascular death.

Identifying OHCA patients without ST-segment elevation who may benefit from an immediate invasive approach remains a clinically challenging task. Standard diagnostic tools such as ECG and troponin levels are poor predictors of acute coronary lesions in this setting.[7-9] According to international guidelines, hemodynamic status should determine the decision on CAG timing in OHCA patients without ST-segment elevation.[10-12] Unstable patients should undergo immediate CAG, on the basis of the results of the SHOCK (Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock) trial,[24] which showed a survival benefit of early revascularization in patients with acute MI complicated by cardiogenic shock. Conversely, a delayed invasive approach is advised for stable OHCA patients without ST-segment elevation, on the basis of the consistent results of the COACT and TOMAHAWK trials,[13,14] which did not show a mortality difference between an immediate invasive strategy and a delayed invasive strategy. Of note, the frequency of relevant CAD or acute coronary occlusion in these 2 RCTs was much lower than in observational studies, which included both hemodynamically stable and unstable OHCA patients.[6,15-17] Thus, it remains unclear whether hemodynamic instability is a reliable predictor of acute coronary occlusions and is the only parameter to consider when deciding the timing of CAG in OHCA patients without ST-segment elevation.

We assessed for the first time, to the best of our knowledge, the frequency of acute coronary occlusions separately in stable and unstable OHCA patients without ST-segment elevation and applied similar definitions of hemodynamic stability as in the COACT and TOMAHAWK trials.[13,14] Therefore, stable OHCA patients fulfilled criteria similar to those of the patients included in these 2 RCTs. By applying these definitions of hemodynamic stability, 56% of OHCA patients were unstable. The relatively high proportion of unstable OHCA patients is explained by the exclusion of conscious OHCA patients, who are less likely to present with unstable hemodynamics,[20] and is consistent with the findings of previous studies, which reported values between 10% and 69%.[25] We found that approximately 20% of OHCA patients without ST-segment elevation presented with acute coronary occlusion. This frequency was in keeping with the 24% to 39% reported in previous observational studies,[6,15-17] but it was 2 times higher than in PEARL (Early Coronary Angiography Versus Delayed Coronary Angiography) (overall, 11.0%; 14.2% in the early CAG arm and 4.2% in the no early CAG arm) [26] and 3 times higher than in the COACT trial (overall, 5%; 3.4% in the early CAG arm and 7.6% in the delayed CAG arm).[14] This information was not reported in the TOMAHAWK and EMERGE (Emergency vs Delayed Coronary Angiogram in Survivors of Out-of-Hospital Cardiac Arrest) trials (Supplemental Table 7).[13,27] Possible explanations for these discrepancies are applications of different patients' selection criteria in real-world situations and RCTs or slightly different definitions of acute coronary occlusions.

Acute coronary occlusion was found in a similar proportion of hemodynamically stable and unstable patients (19% vs 24%); its presence cannot be predicted by hemodynamic instability but may be suspected in the presence of chest pain before cardiac arrest and an initial shockable rhythm. These easily assessable variables should be used in clinical routine to identify patients more accurately who may benefit from early CAG. Moreover, potential future RCTs comparing an immediate invasive strategy vs a delayed invasive strategy could consider these characteristics as inclusion criteria to increase the likelihood of acute coronary occlusion.

OHCA patients with acute coronary occlusions had a 3-fold higher risk of cardiovascular death compared with patients without these occlusions. A potential prognostic benefit of early CAG or PCI in patients with acute coronary occlusion cannot be assessed with our observational data and is beyond the scope of this analysis; however, it is likely given the mortality benefit of primary PCI in patients with acute coronary syndrome.[12,28] Acute coronary occlusion had no impact on all-cause mortality. All-cause mortality was predicted by advanced age and unfavorable cardiac arrest features, such as nonshockable rhythm, unwitnessed cardiac arrest, longer no-flow time, and CPR duration. Hemodynamic status was independently associated neither with cardiovascular nor with all-cause death.

TABLE 2 Cardiac Arrest Details

	OHCA Stable (n = 169)	OHCA Unstable (n = 217)	*P* Value[a]
Symptoms preceding cardiac arrest	169, 45 (27)	217, 77 (35)	0.077
Dyspnea	18 (40)	77, 35 (45)	0.576
Chest pain	19 (43)	77, 27 (35)	0.438
Unspecific discomfort	13 (29)	77, 24 (31)	0.841
Cardiac arrest location	169	217	0.513
At home	64 (38)	95 (44)	0.253
In presence of EMS	8 (5)	11 (5)	1.000
Public area	88 (52)	103 (47)	0.412
Health facility (excluding hospital)	3 (2)	5 (2)	1.000
Unknown	6 (4)	3 (1)	0.188
First monitored rhythm	169	217	0.049
Shockable rhythm	130 (77)	145 (67)	0.032
Nonshockable rhythm	36 (21)	70 (32)	0.021
Unknown	3 (2)	2 (1)	0.657
Witnessed cardiac arrest	169, 142 (84)	217, 180 (83)	0.890
Cardiac arrest witness	142	179	0.450
Not professional	127 (89)	152 (85)	0.248
EMS	12 (8)	20 (11)	0.458
Physician	3 (2)	7 (4)	0.521
Bystander CPR	169, 119 (70)	216, 138 (64)	0.192
EMS CPR	169, 142 (84)	215, 209 (97)	<0.001
No-flow time,[b] min	153, 3.3 ± 5.3	194, 3.7 ± 5.5	0.456
Time from CA to EMS CPR, min	141, 10.8 ± 6.0	205, 11.1 ± 6.7	0.655
CPR duration, min	169, 23.7 ± 15.7	216, 28.2 ± 21.2	0.022
Time from CA to ROSC, min	159, 27.1 ± 16.5	07, 32.1 ± 21.9	0.016
Shock delivered	168, 140 (83)	216, 151 (70)	0.003
Number of shocks delivered	140, 3.3 ± 2.7	149, 3.7 ± 3.2	0.214
Time from CA to first shock, min	132, 11.0 ± 8.0	139, 12.0 ± 6.3	0.248
Epinephrine	169, 107 (63)	217, 165 (76)	0.007
Amiodarone	169, 54 (32)	217, 70 (32)	1.000
Glucose on admission, mmol/L	166, 13.29 ± 4.59	213, 14.16 ± 5.52	0.105
Lactate on admission, mmol/L	146, 5.46 ± 3.24	188, 7.47 ± 4.47	<0.001
pH on admission	153, 7.22 ± 0.13	201, 7.13 ± 0.17	<0.001

Values are n, mean ± SD or n (%). [a]*P* values from Student's *t*-tests (continuous variables), chi-square tests (counts), or Fisher exact test (counts for 2×2 comparisons). [b]Time between cardiac arrest and start of bystander or professional cardiopulmonary resuscitation.

EMS = emergency medical service; ROSC = return of spontaneous circulation; other abbreviations as in Table 1.

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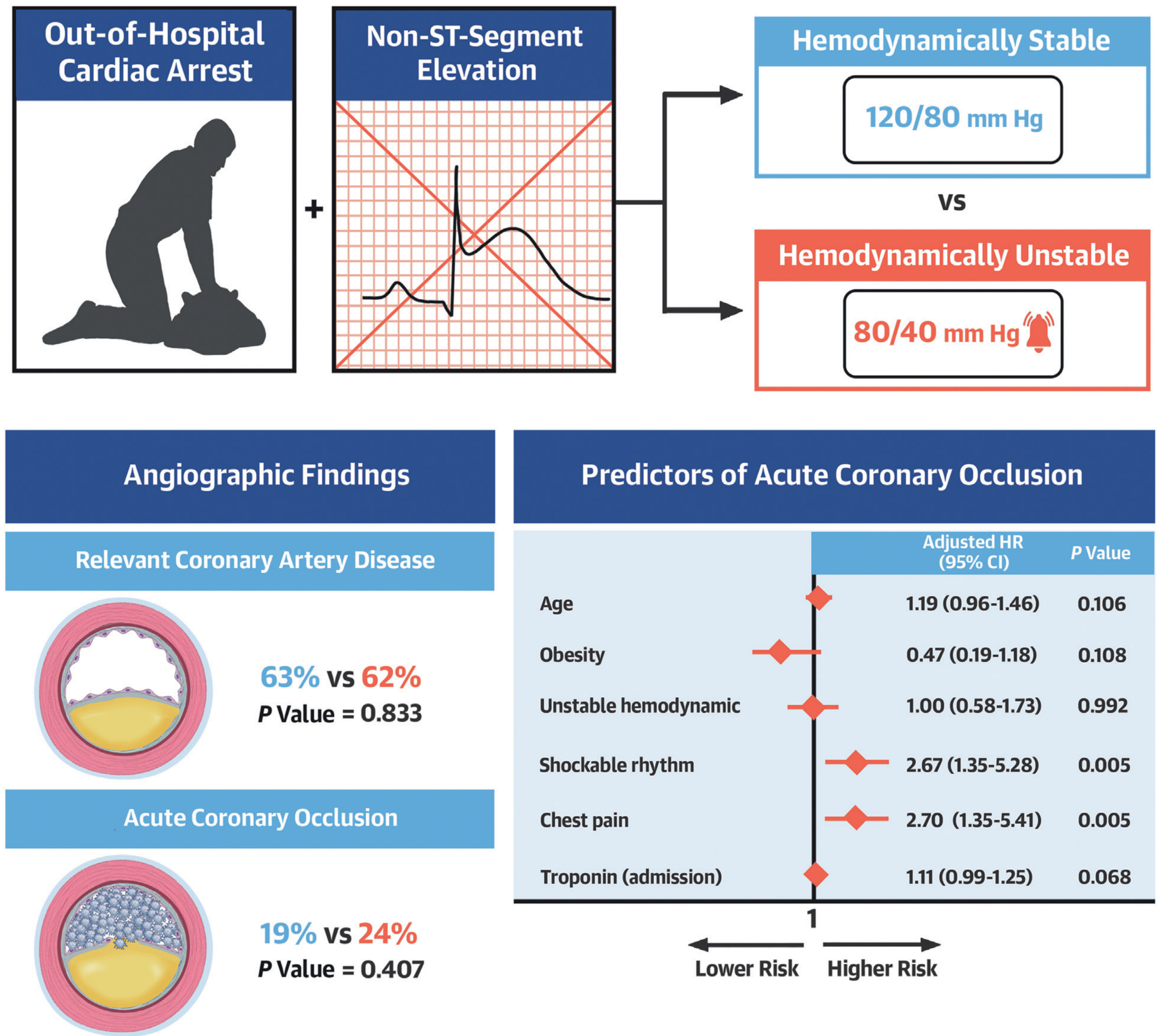
CENTRAL ILLUSTRATION Acute Coronary Occlusions in Patients With Out-of-Hospital Cardiac Arrest Without ST-Segment Elevation

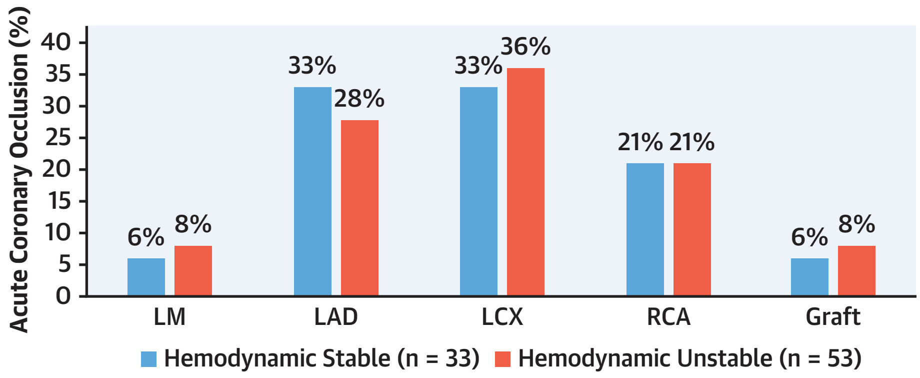


Spirito A, et al. J Am Coll Cardiol. 2023;81(5):446-456.

Unconscious patients after out-of-hospital cardiac arrest without ST-segment elevation on electrocardiography and referred to catheterization laboratory were stratified into hemodynamically stable and unstable. The frequency of relevant coronary artery disease (visual stenosis >50%) and acute coronary occlusion (lesion with Thrombolysis In Myocardial Infarction flow grade 0 or 1 with evidence of thrombus) was similar in the 2 groups. Logistic regression was used to identify predictors of acute coronary occlusion through a forward stepwise approach with a criterion of $P < 0.2$ from a pool of 18 variables (Supplemental Table 2). Predictors were shockable rhythm (ventricular tachycardia or ventricular fibrillation) and chest pain before out-of-hospital cardiac arrest, but not unstable hemodynamic status.

Similarly, previous prognostic scores for OHCA patients, such as the MIRACLE 2 (Missed [unwitnessed] arrest, Initial non-shockable rhythm, Non-reactivity of pupils, Age, Changing intra-arrest rhythms, Low pH <7.20, and Epinephrine administration), OHCA (Out-of-Hospital Cardiac Arrest), NULL-PLEASE (Nonshockable rhythm, Unwitnessed arrest, Long no-flow or Long low-flow period, blood PH <7.2, Lactate >7.0 mmol/L, End-stage chronic kidney disease on dialysis, Age ≥85 years, Still resuscitation,

FIGURE 2 Location of Acute Coronary Occlusions



Among 386 unconscious out-of-hospital cardiac arrest patients without ST-segment elevation, 86 presented with an acute coronary occlusion, which was defined as a lesion with Thrombolysis In Myocardial Infarction flow grade 0 or 1 and evidence of thrombus. If a patient presented with multiple acute coronary occlusions, the occlusion located in the largest vessel or most proximally in the same vessel was reported. Acute coronary occlusions were similarly distributed across vessels (chi-square test $P = 0.641$). LAD = left anterior descending coronary artery; LCX = left circumflex coronary artery; LM = left main coronary artery; RCA = right coronary artery.

and Extracardiac cause), and CAHP (Cardiac Arrest Hospital Prognosis), did not include hemodynamic instability.[29,30] Because hemodynamic instability in OHCA patients is highly related to the severity of post-cardiac arrest syndrome,[31] the inclusion of cardiac arrest variables such as CPR duration, lactate values, or pH in the predictive model may attenuate the association of hemodynamic instability with fatal outcomes as a result of multicollinearity. The high prevalence of noncardiac (ie, neurologic) death in OHCA patients confirms the importance of assessing the likelihood of an adverse neurologic outcome to avoid futile interventions.[32,33]

STUDY LIMITATIONS. First, our study was conducted at a single, albeit largest, tertiary cardiovascular care center in Switzerland. Although the number of OHCA patients included was relatively high, the generalizability of the results may be limited. Second, no conclusion can be drawn about the effect of PCI or of immediate CAG vs delayed CAG. These 2 approaches could not be compared in this cohort because very few patients (<5%) underwent delayed CAG. The association between specific patients' procedural or cardiac arrest characteristics, including acute coronary occlusion, and adverse outcomes is statistical and cannot be interpreted as a cause-and-effect relationship. The type, number, and dose of vasopressors, as well as hemodynamic parameters over time, were not collected; therefore, we were not able to assess the duration or severity of hemodynamic instability further. Finally, the results apply only to OHCA patients without ST-segment elevation who undergo or are undergoing CAG.

CONCLUSIONS

In OHCA patients without ST-segment elevation, acute coronary occlusion was found in 1 in 5 patients, and its frequency did not differ between hemodynamically stable and hemodynamically unstable patients. Acute coronary occlusion was associated with

TABLE 3 Kaplan-Meier Event Rates and Unadjusted Risk for Clinical Outcomes at 1 Year

	OHCA Stable (n = 169)	OHCA Unstable (n = 217)	Unstable vs Stable	
			HR (95% CI)	*P* Value
Death	73 (43.3)	129 (59.6)	1.62 (1.22-2.16)	<0.001
Cardiovascular	20 (14.6)	48 (27.0)	2.17 (1.29-3.66)	0.004
Noncardiovascular	53 (33.1)	81 (43.8)	1.41 (1.00-2.00)	0.050
Recurrent myocardial infarction	3 (2.2)	3 (2.8)	0.95 (0.19-4.70)	0.945
Definite stent thrombosis	4 (2.8)	2 (1.6)	0.44 (0.08-2.43)	0.350
Unplanned revascularization	9 (8.4)	3 (2.8)	0.33 (0.09-1.23)	0.098
Any stroke	4 (3.2)	5 (3.4)	1.18 (0.32-4.40)	0.806
Ischemic stroke	3 (2.6)	4 (2.2)	1.26 (0.28-5.62)	0.766
Hemorrhagic stroke	1 (0.6)	1 (1.2)	0.96 (0.06-15.54)	0.980
BARC 3 or 5	15 (11.8)	27 (17.9)	1.69 (0.90-3.18)	0.105
BARC 3	14 (11.2)	25 (16.8)	1.69 (0.88-3.25)	0.118
BARC 4	2 (2.0)	1 (0.5)	0.49 (0.04-5.44)	0.562
BARC 5	1 (0.6)	2 (1.1)	1.66 (0.15-18.40)	0.678

Values are n (%) unless otherwise indicated. Continuity correction with *P* value from Fisher exact test in case of no events in 1 group. Only counting the first instance of each event (sub)type per patient. Cox's regressions with *P* values from Wald tests.

BARC = Bleeding Academic Research Consortium; OHCA = Out-of-hospital cardiac arrest.

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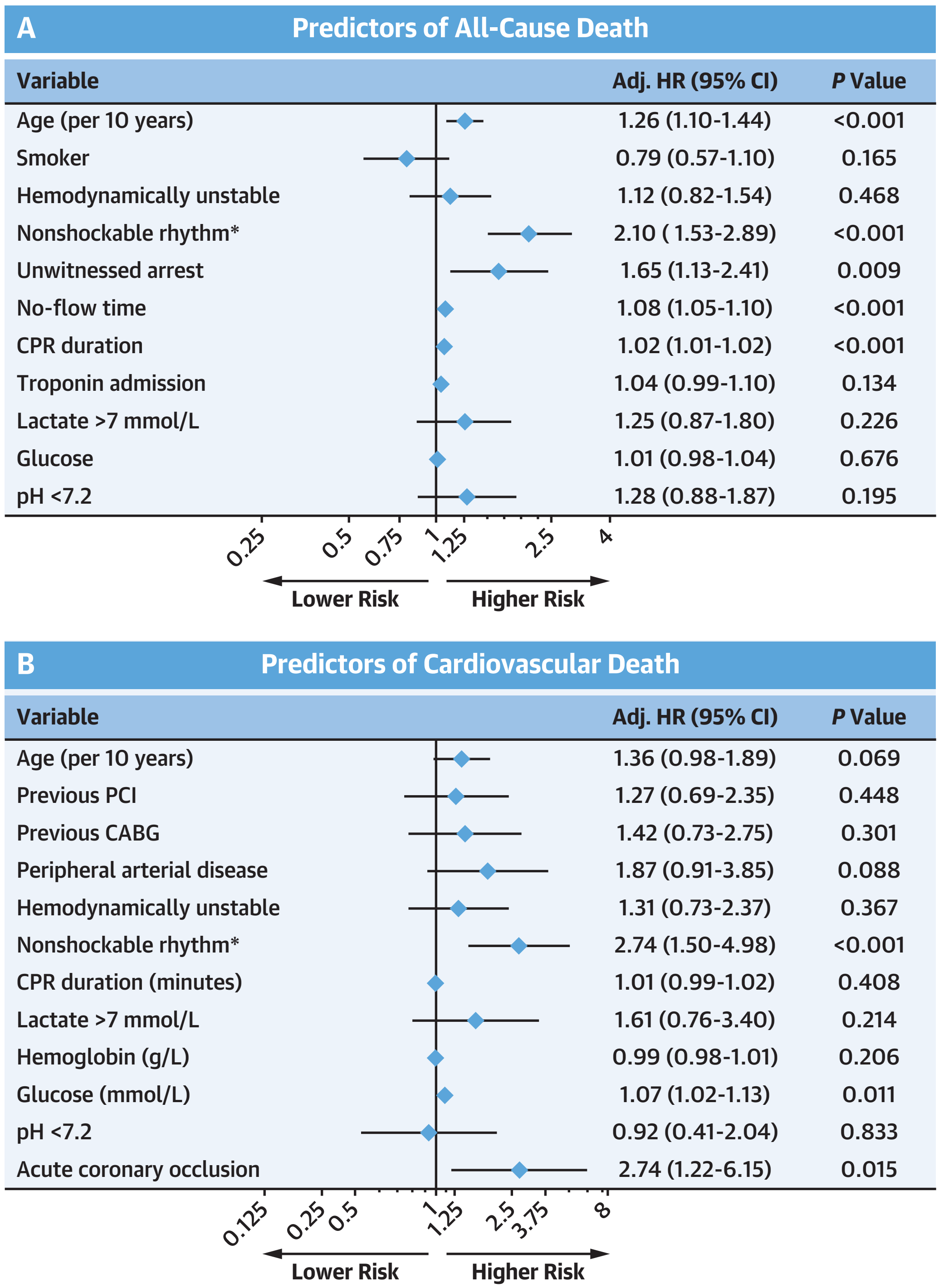
FIGURE 3 Predictors of All-Cause Death and Cardiovascular Death



Predictors of **(A)** all-cause death and **(B)** cardiovascular death. Results of a multivariable Cox regression model after forward stepwise selection from a pool of 25 variables (Supplemental Tables 5 and 6). Acute coronary occlusion was among the strongest predictors of cardiovascular death. Hemodynamic status predicted neither all-cause death nor cardiovascular death. *Pulseless electrical activity or asystole. Adj. = adjusted; CABG = coronary artery bypass graft; CPR = cardiopulmonary resuscitation; PCI = percutaneous coronary intervention.

a nearly 3-fold increased risk of cardiovascular death and was predicted by chest pain before cardiac arrest and a shockable rhythm but not by hemodynamic instability. These factors rather than hemodynamic status may better identify patients with an acute coronary occlusion among OHCA patients without ST-segment elevation.

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ADDRESS FOR CORRESPONDENCE: Dr Lorenz Räber, Department of Cardiology, Bern University Hospital, CH-3010 Bern, Switzerland. E-mail: lorenz.raeber@insel.ch.

PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS: Acute coronary occlusions are present in 1 in 5 patients with OHCA without ST-segment elevation, irrespective of hemodynamic status. Acute coronary occlusions are typically associated with chest pain before cardiac arrest and an initial shockable rhythm.

TRANSLATIONAL OUTLOOK: Further randomized trials are needed to assess the benefit of immediate vs delayed coronary angiography in patients with non-ST-segment elevation OHCA.

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KEY WORDS coronary angiography, coronary occlusion, death, non–ST-segment elevation, out-of-hospital cardiac arrest

APPENDIX For a supplemental methods, tables, and figures, please see the online version of this paper.